

WHAT IS CLAIMED IS:

1. A radio communication system comprising a base station for performing radio communication with a radio communication terminal; and a control station connected to the base station via an optical transmission line,

said base station comprising:

a variable beam-pattern array antenna which comprises a plurality of antenna elements and which can change directivity in accordance with a position of said radio communication terminal;

base station side frequency conversion means configured to subject received signals received from said radio communication terminal via said plurality of antenna elements to frequency conversion to different bands;

sub-carrier multiplexing signal generation means configured to combine a plurality of signals subjected to the frequency conversion by said base station side frequency conversion means to generate a sub-carrier multiplexing signal; and

base station side transmission means configured to transmit said sub-carrier multiplexing signal to said control station via said optical transmission line,

said control station comprising:

control station side frequency conversion means configured to branch said sub-carrier multiplexing signal transmitted from said base station via said optical transmission line to signals received by said plurality of antenna elements, and performing the frequency conversion to obtain the signals of the same frequency band for each of the branched signals;

beam calculation means configured to obtain a weighting coefficient to control directivity of said plurality of antenna elements;

weighting means configured to perform weighting based on said weighting coefficient; and

received signal generation means configured to generate the received signal by combining said branched signals that frequency is converted by said control station side frequency

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said control station comprising:

control station side branching means configured to branch a signal correlated with a transmitted signal transmitted to said radio communication terminal from said variable beam-pattern array antenna for said plurality of antenna elements;

weighting means configured to weight based on a weight control signal for the signals of the respective antenna elements relating to the transmitted signal transmitted from said variable beam-pattern array antenna to said radio communication terminal;

control station side frequency conversion means configured to convert frequency to respective different bands;

sub-carrier multiplexing signal generation means configured to combine the respective signals converted to the different bands subjected to the frequency conversion by said control station side frequency conversion means to generate a sub-carrier multiplexing signal; and

transmission means configured to transmit said sub-carrier multiplexing signal to said base station via said optical transmission line,

said base station comprising:

base station side branching means configured to branch said sub-carrier multiplexing signal transmitted from said control station via said optical transmission line for said plurality of antenna elements; and

base station side frequency conversion means configured to subject the respective signals branched by said base station side branching means to the signals of the same frequency band, wherein

said plurality of antenna elements transmit the respective signals subjected to the frequency conversion by said base station

side frequency conversion means to said radio communication terminal.

3. The radio communication system according to claim 1 wherein said base station further comprises:

a first local oscillator for supplying a first reference signal as a frequency conversion reference to said base station side frequency conversion means,

said control station further comprises:

a second local oscillator for supplying a second reference signal as the frequency conversion reference to said control station side frequency conversion means, and

said second local oscillator outputs said second reference signal which has a predetermined phase relation with said first reference signal so that said control station side frequency conversion means output the signal maintaining a relative phase difference among the respective received signals of said plurality of antenna elements.

4. The radio communication system according to claim 2 wherein said base station further comprises:

a first local oscillator for supplying a first reference signal as a frequency conversion reference to said base station side frequency conversion means,

said control station further comprises:

a second local oscillator for supplying a second reference signal as the frequency conversion reference to said control station side frequency conversion means, and

said second local oscillator outputs said second reference signal which has a predetermined phase relation with said first reference signal so that said control station side frequency conversion means output the signal maintaining a relative phase difference among the respective received signals of said plurality of antenna elements.

5. The radio communication system according to claim 1 wherein said base station comprises:

reference signal generation means configured to generate a reference signal; and

reference signal transmission means configured to

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directly transmit the generated reference signal for superposing the reference signal to said sub-carrier multiplexing signal and transmitting the signal to said control station, and

said base station side frequency conversion means and said control station side frequency conversion means perform the frequency conversion based on the same reference signal generated by said reference signal generation means.

6. The radio communication system according to claim 2 wherein said control station comprises:

reference signal generation means configured to generate a reference signal; and

reference signal transmission means configured to directly transmit the generated reference signal for superposing the reference signal to said sub-carrier multiplexing signal and transmitting the signal to said base station, and

said base station side frequency conversion means and said control station side frequency conversion means perform the frequency conversion based on the same reference signal generated by said reference signal generation means.

7. The radio communication system according to claim 1 wherein said control station comprises:

addition means configured to superpose a signal correlated with the transmitted signal transmitted to said radio communication terminal from said variable beam-pattern array antenna and a signal correlated with said weighting coefficient; and

control station side transmission means configured to transmit the signal superposed by said addition means to said base station,

said base station comprises:

first branching means configured to branch the signal transmitted from said control station to the signal correlated with said transmitted signal, and the signal correlated with said weighting coefficient;

second branching means configured to branch the branched signal correlated with said transmitted signal to the same number as the number of said antenna elements; and

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base station side weighting means configured to weight the signals correlated with said transmitted signal and branched by said second branching means based on a weighting control signal correlated with said weighting coefficient;

wherein said antenna elements transmit the respective signals subjected to the base station side weighting means to said radio communication terminals.

8. The radio communication system according to claim 7 wherein

said base station comprises:

first optical/electric conversion means configured to convert a first optical signal transmitted from said control station via said transmission line to an electric signal;

separation means configured to separate the electric signal converted by the first optical/electric conversion means to the transmitted signal for said radio communication terminal and a beam control signal for controlling the radiation beam-pattern of said variable beam-pattern array antenna;

antenna control means configured to control the radiation beam-pattern of a transmission/reception beam of said variable direction antenna based on said beam control signal;

base station side transmission means configured to transmit the transmitted signal for said radio communication terminal to said radio communication terminal via said variable beam-pattern array antenna;

first electric/optical conversion means configured to optically modulate the signal subjected to frequency multiplexing by said sub-carrier multiplexing signal generation means to generate a second optical signal, and transmitting the second optical signal to said control station via said optical transmission line; and

base station side transmission frequency conversion means configured to convert the transmitted signals for said radio communication terminal separated by said separation means to a radio frequency signal and supplying the radio frequency signal to said base station side transmission means, and

said control station comprises:

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second optical/electric conversion means configured to convert said second optical signal transmitted from said base station to the electric signal;

demultiplex means configured to divide the electric signal converted by said second optical/electric conversion means to said plurality of frequency signals before multiplexing;

control station side transmission frequency conversion means configured to convert the respective signals divided by said demultiplex means to the signals of the same frequency;

weighting means configured to weight the signals subjected to the frequency conversion by said third frequency conversion means with respect to a phase and a signal intensity;

combiner means configured to combine the respective signals weighted by said weighting means;

demodulation means configured to demodulate the received signal based on the signal combined by said combiner means;

level detection means configured to detect a maximum intensity and/or an intensity distribution of the signals subjected to the frequency conversion by said control station side frequency conversion means, and generating said beam control signal based on the detection result;

control station side frequency multiplexing means configured to multiplex the transmitted signal for said radio communication terminal and said beam control signal; and

second electric/optical conversion means configured to optically modulate the signal multiplexed by said control station side frequency multiplexing means to generate said first optical signal, and transmitting the first optical signal to said base station via said optical transmission line.

9. The radio communication system according to claim 8 wherein

said base station comprises received signal selection means configured to select some signals from signals correlated with the respective received signals received from said radio communication terminal via said plurality of antenna elements based on said beam control signal, and

said frequency multiplexing means multiplex only the

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signals selected by said received signal selection means.

10. The radio communication system according to claim 1 wherein

said base station comprises the variable beam-pattern array antenna constituted of first to n-th antenna elements (n is a positive integer),

at least one of said base station and said control station comprises phase compensation means configured to compensate a phase fluctuation amount generated by a signal propagation path between said base station and said control station, and a signal processing on the side of said base station and said control station, and

said phase compensation means establish a relation

$$\begin{aligned}\phi_1 + 2m_1\pi &= \phi_2 + 2m_2\pi = \phi_3 + 2m_3\pi \\ &= \dots = \phi_n + 2m_n\pi \quad (m_1, \dots, m_n \text{ are integers})\end{aligned}$$

in respective phase change amounts ϕ_1 to ϕ_n in blocks of said antenna elements disposed on said base station and said weighting means disposed on said control station with respect to the received signal of said variable beam-pattern array antenna and the transmitted signal to said variable beam-pattern array antenna.

11. The radio communication system according to claim 2 wherein

said base station comprises the variable beam-pattern array antenna constituted of first to n-th antenna elements (n is a positive integer),

at least one of said base station and said control station comprises phase compensation means configured to compensate a phase fluctuation amount generated by a signal propagation path between said base station and said control station, and a signal processing on the side of said base station and said control station, and

said phase compensation means establishes a relation

$$\begin{aligned}\phi_1 + 2m_1\pi &= \phi_2 + 2m_2\pi = \phi_3 + 2m_3\pi \\ &= \dots = \phi_n + 2m_n\pi \quad (m_1, \dots, m_n \text{ are integers})\end{aligned}$$

in respective phase change amounts ϕ_1 to ϕ_n in blocks of said antenna elements disposed on said base station and said weighting

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means disposed on said control station with respect to the received signal of said variable beam-pattern array antenna and the transmitted signal to said variable beam-pattern array antenna.

12. A radio communication system comprising:

a base station provided with a variable directional array antenna whose directivity changes by an electric signal for supplying power to a plurality of antenna elements; and

a control station provided with a signal calculation circuit for performing weighting of electric signal applied to said plurality of antenna elements,

said base station being connected to said control station via an optical transmission line,

wherein the electric signal for supplying the power to said plurality of antenna elements is transmitted to said base station from said control station via said optical transmission line, and

the signal transmitted via said optical transmission line is constituted by multiplexing an electric signal obtained by subjecting the electric signal for supplying the power to said plurality of antenna elements to frequency conversion to different frequencies by a plurality of local oscillator outputs different in frequency from one another, with said local oscillator outputs.

13. A radio communication system comprising:

a base station provided with an array antenna including a plurality of antenna elements; and

a control station provided with a beam forming network for deriving a desired signal from a received signal of said variable directional array antenna,

said base station being connected to said control station via an optical transmission line,

wherein an electric signal received by said plurality of antenna elements is transmitted to said control station from said base station via said optical transmission line, and

the signal transmitted via said optical transmission line is constituted by multiplexing an electric signal obtained by

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subjecting the electric signal received by said plurality of antenna elements to frequency conversion to different frequencies by a plurality of local oscillator outputs different in frequency from one another, with said local oscillator outputs.

14. A radio communication system comprising: a base station for performing radio communication with a radio communication terminal; and a control station connected to the base station via an optical transmission line, wherein

said base station comprises:

a plurality of antenna elements different in directivity from one another;

first optical/electric conversion means configured to convert a first optical signal transmitted from said control station via said optical transmission line to an electric signal;

separation means configured to separate the electric signal converted by the first optical/electric conversion means to a transmitted signal for said radio communication terminal and an antenna selection signal for selecting said plurality of antenna elements;

antenna control means configured to select any one of said plurality of antenna elements based on said antenna selection signal to control the antenna element;

transmission means configured to transmit the transmitted signal for said radio communication terminal to the radio communication terminal via said antenna element;

first frequency multiplexing means configured to subject signals correlated with respective received signals received from said radio communication terminal via said antenna element to frequency multiplexing; and

first electric/optical conversion means configured to optically modulate the signal subjected to the frequency multiplexing by the frequency multiplexing means to generate a second optical signal, and transmitting the second optical signal to said control station via said optical transmission line, and

said control station comprises:

second optical/electric conversion means configured to convert said second optical signal transmitted from said base

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station to the electric signal;

demultiplex means configured to divide the electric signal converted by said second optical/electric conversion means to said plurality of frequency signals before multiplexing;

weighting means configured to weight the signals correlated with the respective frequency signals divided by said demultiplex means with respect to a phase and/or a signal intensity;

combiner means configured to combine the respective signals weighted by said weighting means;

demodulation means configured to demodulate the received signal based on the signal combined by said combiner means;

level detection means configured to detect a maximum intensity and/or an intensity distribution of the signals correlated with the respective frequency signals divided by said demultiplex means, and generating said antenna selection signal based on the detection result;

second frequency multiplexing means configured to multiplex the transmitted signal for said radio communication terminal with said antenna selection signal; and

second electric/optical conversion means configured to optically modulate the signal multiplexed by said second frequency multiplexing means to generate said first optical signal, and transmitting the first optical signal to said base station via said optical transmission line.

15. A radio communication system comprising: a radio communication terminal; a base station for performing radio communication with the radio communication terminal; and a control station connected to the base station via an optical transmission line,

said base station comprising:

an array antenna comprising a plurality of antenna elements; and

feedback means configured to feed respective transmitted signals corresponding to said antenna elements transmitted from said control station via said optical transmission line back to said control station via said optical transmission line,

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said control station comprising:

comparing detection means configured to compare at least two signals among said respective transmitted signals fed back from said feedback means, and detecting a phase difference and/or an amplitude fluctuation amount; and

compensation means configured to compensate for the respective transmitted signals corresponding to said plurality of antenna elements based on the phase difference and/or the amplitude fluctuation amount detected by said comparing detection means.

16. The radio communication system according to claim 15 wherein said feedback means further comprises:

pilot signal insertion means configured to insert a pilot signal with a known phase and/or amplitude into the respective transmitted signals to said plurality of antenna elements; and

transmission means configured to multiplex respective output signals of said pilot signal insertion means and transmitting the signals to said control station via said optical transmission line, and

said comparing detection means comprises:

first detection means configured to detect the phase difference and/or the amplitude fluctuation amount of a receiver path to said control station from said base station based on said pilot signal; and

second detection means configured to detect the phase difference and/or the amplitude fluctuation amount of a transmitter path to said base station from said control station based on the detection result of said first detection means.

17. The radio communication system according to claim 15 wherein

said feedback means comprise:

combiner means configured to combine the respective transmitted signals to said plurality of antenna elements with received signals in said corresponding antenna elements;

pilot signal insertion means configured to insert a pilot signal with a known phase and/or amplitude into the respective signals synthesized by said combiner means;

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a plurality of first frequency conversion means configured to convert respective output signals of said pilot signal insertion means to different frequency signals;

frequency multiplexing means configured to multiplex respective output signals of said plurality of first frequency conversion means; and

electric/optical conversion means configured to optically modulate the signal multiplexed by said frequency multiplexing means and transmitting the signal to said control station via said optical transmission line,

said control station comprises:

optical/electric conversion means configured to convert a optical signal transmitted from said electric/optical conversion means via said optical transmission line to an electric signal;

demultiplex means configured to divide the electric signal converted by said optical/electric conversion means to a plurality of different frequency signals; and

a plurality of second frequency conversion means configured to convert the respective signals divided by said demultiplex means to the signals of the same frequency, and

said comparing detection means comprise:

extraction means configured to extract said pilot signal and a feedback signal of the transmitted signal to said plurality of antenna elements from respective output signals of said plurality of second frequency conversion means;

first detection means configured to detect the phase difference and/or the amplitude fluctuation amount of a receiver path to said control station from said base station based on said pilot signal; and

second detection means configured to detect the phase difference and/or the amplitude fluctuation amount of a transmitter path to said base station from said control station based on the detection result of said first detection means.

18. A radio communication system comprising:

a base station for performing radio communication with a radio communication terminal; and a control station connected

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to the base station via an optical transmission line,

said base station comprising:

an array antenna comprising a plurality of antenna elements; and

feedback means configured to feed respective transmitted signals corresponding to said antenna elements transmitted from said control station via said optical transmission line back to said control station via said optical transmission line,

said control station comprising:

comparing detection means configured to compare at least one of said respective transmitted signals corresponding to said plurality of antenna elements with at least one of the signals fed back from said feedback means, and detecting an absolute phase difference and/or an absolute amplitude fluctuation amount of both signals; and

compensation means configured to compensate for the respective transmitted signals corresponding to said plurality of antenna elements based on the comparison result of said comparing detection means.

19. The radio communication system according to claim 18 wherein said feedback means comprises:

combiner means configured to combine the respective transmitted signals corresponding to said plurality of antenna elements with received signals in said corresponding antenna elements;

a plurality of first frequency conversion means configured to convert the respective signals synthesized by said combiner means to different frequency signals;

frequency multiplexing means configured to multiplex respective output signals of said plurality of first frequency conversion means;

first electric/optical conversion means configured to optically modulate the signal multiplexed by said frequency multiplexing means and transmitting the signal to said control station via said optical transmission line;

base station side switch means configured to select any one of the respective transmitted signals to said plurality of

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antenna elements;

second frequency conversion means configured to subject the transmitted signal selected by said base station side switch means to frequency conversion; and

second electric/optical conversion means configured to optically modulate an output signal of said second frequency conversion means and transmitting the signal to said control station via said exclusive transmission line,

said control station comprises:

first optical/electric conversion means configured to convert a optical signal transmitted from said first electric/optical conversion means via said optical transmission line to an electric signal;

demultiplex means configured to divide the electric signal converted by said first optical/electric conversion means to a plurality of frequency signals;

a plurality of third frequency conversion means configured to convert the respective signals divided by said demultiplex means to the signals of the same frequency;

second optical/electric conversion means configured to convert the optical signal transmitted from said second electric/optical conversion means via said exclusive transmission line to the electric signal; and

control station side switch means configured to select any one of the respective transmitted signals corresponding to said plurality of antenna elements, and

said comparing detection means successively switches said base station side switch means and said control station side switch means, compares the corresponding transmitted signal with the output signal of said second optical/electric conversion means for said antenna elements, and detects the absolute phase difference and/or the absolute amplitude fluctuation amount of the transmitted signal.

20. The radio communication system according to claim 18 wherein

said array antenna is an adaptive antenna which can change directivity of a transmission/reception beam,

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said control station further comprises:

adaptive antenna weighting coefficient calculation means configured to calculate an adaptive antenna weighting coefficient with respect to the phase and amplitude with respect to said respective antenna elements to change the radiation beam-pattern of said adaptive antenna, and

said compensation means comprise:

calibration coefficient calculation means configured to calculate a calibration coefficient for estimating a phase difference and/or an amplitude fluctuation amount of the respective transmitted signals corresponding to said plurality of antenna elements based on the comparison result of said comparing detection means;

weighting coefficient calculation means configured to calculate a transmission weighting coefficient and a reception weighting coefficient based on said adaptive antenna weighting coefficient and said calibration coefficient;

first weighting means configured to perform weighting of the received signals in said plurality of antenna elements based on said reception weighting coefficient; and

second weighting means configured to perform the weighting of the transmitted signals to said plurality of antenna elements based on said transmission weighting coefficient.

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